

IMPLICATIONS OF SO₃ REMOVAL ON MERCURY CAPTURE

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SUMMARY

The reduction of SO₃ to levels of a few ppmv in coal-fired boiler exhaust gases upstream of mercury removal/ fly ash collection systems can have implications on the effectiveness and cost of mercury removal. Since EPA's Clear Air Mercury Rule, issued in 2005, will require mercury emission reductions from utility power plants of nearly 70 percent, studies are being performed to identify the most cost effective methods to achieve the required mercury reductions. Recent measurements of samples from coal-fired power plants show that mercury removal by fly ash and injected activated carbon can be enhanced by significantly reducing flue gas SO₃ levels upstream of existing particulate control devices. At least two mechanisms have been suggested to explain this observed improvement in mercury removal:

- lower SO₃ concentrations in the flue gas reduce the competition with mercury for active sorption sites,
- lower SO₃ concentrations allow operation at lower gas temperatures which tend to increase the mercury capture capacity of activated carbon and fly ash.

Laboratory tests conducted with activated carbon samples under simulated flue gas conditions showed a dependence of gas temperature on the sorption capacity. Tests were performed with two forms of mercury, namely, elemental mercury (Hg(o)) and mercuric chloride (HgCl₂), a surrogate for oxidized mercury species. Over the range of temperatures from 225 to 375F, the adsorption capacity decreases by about an order of magnitude. In addition to varying temperature, the sorption capacity of activated carbon also depends on the flue gas mercury concentration. Therefore, to predict actual removal the relationship of the equilibrium distribution of mercury species between the sorbent and the vapor phase needs to be characterized as a function of temperature, mercury concentration and the levels of other key species in the flue gas.

The interaction of mercuric chloride with activated carbon has been determined to involve a physical adsorption mechanism that was modeled as a Freundlich isotherm relationship. The reaction of elemental mercury with activated carbon appears to involve a more complicated mechanism. Experimental data indicate that the uptake of elemental mercury by activated carbon proceeds by the oxidation of elemental mercury on the surface of the carbon. In the presence of HCl, the oxidized form was measured to be mercuric chloride. An adsorption model was used to determine the Freundlich isotherm

parameters, for candidate sorbents, by fitting time dependent mercury breakthrough curves obtained from dilute-phase, packed bed reactor tests. These sorption related models were coupled with economic calculations to provide a method to estimate the cost impacts on mercury removal due to sorbent properties and prices.

Additionally, estimates of the sorption capacity of mercury onto fly ash were determined from measurements of the mercury content of collected fly ash samples from a number of sites representing a range of operating conditions. These results show that the sorption capacities for fly ashes are roughly a tenth of that of activated carbon. The mercury adsorption capacity of a given fly ash was found to be a function of its un-burnt carbon content.

Laboratory and field test results have also shown that the amount of mercury captured by the ash collected in an ESP increases at low SO₃ levels. The mercury concentrations in ash samples from several sites increased by factors of 10 to 20 over baseline conditions as the SO₃ levels were decreased below 5 ppmv. Pilot plant test results have shown similar increases in mercury removal by fly ash and activated carbon at reduced SO₃ levels.

The economic implications of improving mercury removal by increasing the capacity of fly ash and activated carbon can be significant. Cost estimates have been made that compare the capital and operating costs of carbon injection systems as a function of the sorbent particle size and mercury adsorption capacity. In general, reducing the particle size of the sorbent tends to reduce the amount required to achieve a given mercury reduction.

The average particle sizes of standard activated carbons that have been tested for mercury reduction in flue gases are typically in the range of 15 to 20 microns. However, model results show that the amount of activated carbon needed to achieve a given mercury removal can be significantly reduced if the sorbent particle size is reduced into the range of 2 to 5 microns. For sorbents injected in this size range, the mercury removal efficiency also becomes more dependent on the mercury capacity of the sorbent.

Research is presently being conducted to optimize the injection technology required to effectively introduce activated carbon, that has been wet ground to reduce the particle size, as a slurry into hot flue gas. The size distribution of the resulting dried particles, as determined using cascade impactor measurements, can be compared with the size distribution in the slurry before injection. While previous laboratory tests indicated that carbon slurries did not lose their sorption capacity upon drying, additional sorption measurements will be conducted to evaluate the effects of any chemicals that may be added to the carbon slurry.